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(54) REINFORCED HOSE AND METHODS AND APPARATUS FOR ITS MANUFACTURE

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No. OF CLAIMS 10

This invention relates to reinforced high pressure hose made from synthetic polymeric materials, which hose conventionally includes an inner tube, at least one reinforcing member of high tensile strength synthetic yarn, and a cover protecting the reinforcing member. The invention further relates to methods and means for the manufacture of these hoses and, in particular, to solvent bonding processes for securing the various components of the hose to each other.

The invention is primarily directed to providing improved reinforced hoses of the synthetic polymeric type in which the various components are solvent-bonded to each other by improved process control and quality control solvent bonding operations. According to one aspect of the invention, at least one reinforcing member comprises a high tensile strength yarn spirally wound and bonded to an inner member of the hose by improved solvent bonding methods.

Discussion of Prior Art Hose Construction.

It has been recognized in the prior art that, in order to make a high quality reinforced high pressure hose from synthetic polymeric materials, it is important to bond the various components of the hose together. It is known that such bonding improves certain properties of the hose, such as kink resistance and retention of fittings under pressure, and, if properly controlled, the bonding will not adversely affect other properties of the hose to a material degree. Some minimal bonding is also desirable to prevent the various components from sliding or pulling back from each other when the hose is cut to length for fittings to be attached.

In addition to these factors, there is a slightly more subtle reason why a suitable bond between the various components of a hose is important. This lies in the fact that the total weight of the materials used in the construction of the hose may be reduced when a proper bond is achieved between the components. Essentially, the reason for this lies in the fact that when the components are bonded to each other, they will function as a monolithic structure and certain desired physical properties of each component will be additive to those certain properties of the other components. Conversely,

when no suitable bond is obtained, certain of the desired physical properties of the components will not be additive, but rather, the components will tend to function, in respect of these certain properties, as three independent and unrelated members.

The importance of the foregoing can be understood by reference both to the importance of bonding the cover to the outer reinforcing member and to the importance of bonding the inner reinforcing member to the inner tube. These are discussed separately below.

A hose, by definition, is a flexible conduit, and it is important that it can be bent to a relatively small radius without kinking, that is, without collapsing the interior diameter of the hose to form a constriction in the hose. As a general rule, kink resistance is a function of the wall thickness of the hose, and when it is desired to increase the kink resistance of the hose, the thickness of the outer cover is increased. If possible, a manufacturer will generally resist increasing the thickness of the outer cover since this will not only add to the cost of the hose, but will also reduce the flexibility of the hose. For these reasons it becomes important to optimize the contribution that the outer cover makes in adding to the kink resistance of the hose. It has now been found that this can be accomplished by providing a secure bond between the cover and the reinforcing member. When a secure bond is so obtained, the contribution of each component to kink resistance is additive, whereas when there is no such bond neither component contributes to the strength of the other to a material degree.

The importance of good bonding can also be explained with regard to the relationship between the reinforcing member and the inner tube. For example, consider the problem of attaching removable fittings to a reinforced hose construction. Here it is conventional to use a fitting that has an outer socket (sleeve) and an inner nipple (mandrel). The socket is slipped over the outer diameter of the hose, and the nipple, which is slightly tapered, is inserted into the interior diameter of the hose. Mating screw threads on the outer socket and the inner nipple are engaged and rotated, causing the tapered end of the nipple to be drawn into fluid-sealing relationship with the

interior of the hose. It can be appreciated that as the nipple is twisted into the hose, that portion of the hose held clamped between the socket and the nipple is placed in shear, and if the torsional forces become excessive, the hose may weaken and fail at this point. Here again it can be appreciated that when the bond between the members of the hose is a good one (in this instance, primarily between the tube and the reinforcing member), resistances to shear will be additive and the members individually so provide a greater resistance to the twisting forces of the fittings than when there is no bond and the members are independent from each other and are free to rotate relative to each other.

Several methods have been used in the past to obtain good adhesion between the various components of reinforced high pressure hose. Perhaps the most popular of these, due to its comparative simplicity in use, is one in which an adhesive is used to bind adjacent components to each other. The use of adhesives, however, generally does not provide the bond characteristics that are desired in the construction of high pressure hoses made from high tensile polymeric materials such as nylon. In these instances while more difficult to control, it has been found desirable to use solvent bonding techniques to obtain satisfactory bonds. In the solvent bonding processes, the polymeric components are brought into contact with one or more solvents that solvate the surfaces of the components and permit them to be united together while in a solvated or softened condition. It is this type of solvent bonding with which the instant invention is concerned.

As mentioned, solvent bonding processes are difficult to control, and it is difficult to achieve uniform and consistent results in production. On the one hand, if process conditions are such that the components are overly exposed to the solvent, the components may be too deeply solvated with an attendant undesirable altering of their physical properties. For example, over-solvation of a high tensile strength synthetic yarn may cause an appreciable reduction in its tensile strength and over-solvation of the tube may cause an increase in the temperature at which it becomes subject to low temperature embrittlement.

At the other extreme, if too little solvent is used, the surface of the components may not be solvated to a sufficient extent to enable union of the components. Therefore, as a generality, it may be said that to achieve best results, the amount of solvation of the surface of the component to be bonded should be limited to the minimum degree that is consonant with obtaining the desired bond strength. As a practical matter, this desideratum has rarely been achieved with any consistency in production.

The above problems encountered in solvent bonding processes become perhaps even more critical when applying a reinforcing member in the form of high tensile strength yarns spirally wrapped, as opposed to braided, over the inner core. Spiral-wrapped reinforced hose has certain advantages over braided reinforced hose. For example, it is somewhat more economical to manufacture since the spiral wrapping can be applied, per lineal foot of hose, at a rate about ten times faster than can a braid. Also, under certain preferred conditions, higher burst strengths may be obtainable when the same amount of yarn is used in the form of a spiral reinforcement rather than in the form of braided reinforcement. While not as important a factor as when metal reinforcing wires are used, it would seem that fibers may be less subject to abrasion between themselves on flexing if the reinforcing is applied as a spiral wrap rather than a braid.

Control over the degree of solvation may be more critical when bonding a spiral-wrapped reinforcing member to an inner tube than it is when bonding a braided reinforcing member to the tube. For this reason, some of the techniques known to the prior art for bonding braided reinforcement to an inner tube may not be completely satisfactory for bonding spiral-wrapped yarns to the inner tube.

For example, reference is made to an accepted bonding technique disclosed in U.S. Patent 2977839. Here the inner tube is caused to travel submerged through an elongated bath of solvent, a braid is then applied to the solvent-wetted surface of the inner tube, and the braided structure is then immediately submerged in a liquid bath to remove the excess solvent from the braid in order to prevent excessive solvation.

This and other prior art processes may be categorized as those that ensure adhesion by first applying an excess amount of solvent to one of the components and then, as soon as the components to be bonded are brought into contact with each other and initial bonding or union is achieved, the excess solvent is immediately washed away in an attempt to prevent excessive solvation. In the case of a braided reinforcement, the process has proved commercially acceptable, although at times somewhat unpredictable. Here it is possible to make use of the open area of the braid to provide access to wash excess solvent away. In the case of a spiral-wrapped reinforcement, however, since adjacent fibers essentially abut directly against each other, it is more difficult to flush the excess solvent radially away from the inner tube, and thus the process becomes even more erratic in terms of process and quality control.

Description of The Invention and Embodiments

According to the invention, the manufacture of reinforced hoses from polymeric material includes the step of contacting a component of the hose, such as the inner tube, with only that minimum quantity of solvent necessary to obtain adequate adhesion between the various components. Excessive solvation is thereby avoided, and the need for any washing step to remove excess solvent is eliminated. Since only a minimum quantity of solvent is utilized, there is little margin for error and close regulation must be assured over the various process variables such as the composition of the solvent bath, and maximum tolerable impurities; the strength of the solvent bath; the temperature of the solvent bath; the viscosity of the solvent bath; the specific gravity of the solvent bath; the detention time of the component within the solvent bath; the time interval after the component leaves the solvent bath until it is contacted with the component to be bonded thereto; and certain additional factors as will be discussed in greater detail below.

The principles and practice of the invention will now be described in more detail in conjunction with the accompanying drawings, wherein:

FIG. 1 is a drawing of a reinforced polymeric hose of the class described, which has been partially cut away;

FIG. 2 is a schematic representation of apparatus for solvating the outer surface of the inner tube and applying a high tensile strength yarn outer covering over the inner tube;

FIG. 3 is a sectional view of a wiping member adapted to be mounted at the exit end of solvation vessels shown in FIGS. 2, 3 and 4;

FIG. 4 is a schematic representation of a modification of the apparatus shown in FIG. 2; and,

FIG. 5 is a schematic representation of apparatus for controlling solvation of the inner nylon core when a high tensile strength yarn is applied by a device having a horizontal axis of rotation.

In FIG. 1 there is shown hose of the type herein described. The hose 2 is comprised of an inner core of a high strength polymeric tubing 4. An inner spiral wrapping 6 of high tensile strength yarn is wound around and is bonded to the inner tube 4. An outer spiral wrapping 7 of high tensile strength yarn is wound in the opposite direction over the inner wrapping 6. The structure is completed by a thin polymeric protective covering 8 which is bonded to the outer wrapping 7. While not shown in the drawings, it should be noted that any number of wrappings can be wound over the inner tube, but preferably, to relieve any unbalanced forces, an even number of wrappings, each of opposite hand, should be used.

FIG. 2 illustrates one form of an apparatus for solvating the surface of an inner tube 4 and bonding it to a reinforcing member 6. The device includes a solvating tank 14 containing a liquid bath of a solvent 15 for solvating the tube 4. An inlet gasket or seal 16 is provided to prevent the solvent 15 from leaking out of the vessel 14 . The vessel 14 is provided with a horizontal leg for receiving tube 4 from the letout wheel 12 and with a vertical leg for directing solvated tube 4 toward the braider or wrapping device 25. A guide 17 is provided at the mid-point of the intersection of the horizontal and vertical legs of the vessel 14.

Provision is made for continuously circulating solvent through vessel 14 by means of solvent inlet orifice 20 and solvent overflow orifice 21. Solvent overflow orifice 21 communicates, via a conduit, with an upper

portion of supply tank 22. A submerged discharge orifice of tank 22 is provided that communicates via a conduit with pump 23 to recirculate solvent via orifice 20 back into a lower portion of the vessel 14.

Various accessories may be provided on the supply tank including an access or supply port 24 for introducing makeup solvent, a valved drain 26 for removing spent solvent or obtaining samples, and a sight glass 27 to monitor the level of solvent within the tank.

As will be pointed out in more detail below, it is important to maintain close control over the temperature of the solvent within the system. Accordingly, the supply tank 22 is equipped with heat exchange means 28 and temperature sensing means 29 for monitoring the temperature within the tank. The heat exchanger 28, as schematically shown in the drawing, can be a simple coil of pipe through which water can be pumped. Depending upon ambient conditions and the temperatures of the bath, either hot or cold water can be circulated through the heat exchanger to maintain the solvent at a desired temperature. While not shown in the drawings, still other auxiliary equipment may sometimes be usefully associated with the supply tank 22, as for example, devices for monitoring the specific gravity and viscosity of the solvent in the system.

In operation, an inner tube 4, stored on reel 12, is paid out and led through the sealing gasket 16 into the interior of the solvating vessel 14. The tube is led around guide 17 and out of the tank 14 by way of wiping member 18. As will be pointed out below in connection with the description of FIG. 3, wiping member 18 removes excess solvent from the tube 4 as it leaves the solvating vessel 14. Immediately thereafter, the solvated tube 4 is wrapped with a high tensile strength reinforcing member 6 by a conventional braiding or wrapping machine 25. The reinforced tubing is then drawn onto takeup reel 26.

FIG. 3 shows the details of construction of a preferred wiping member. The wiping member includes a base section 30 which is fixedly mounted to the vessel 14 by any of many conventional methods, such as by threading, bolting, and so forth. The base 30 has mounted therein an entrance guide

bushing 31 having tapered wall surfaces. Base 30 also includes a recessed portion 32 which receives a wiping gasket 34 having a central circular aperture 36. The gasket 34 is made from a flexible, resilient material, one suitable material being a synthetic rubber sold under the trade name "VITON". While other materials of similar properties may be used, this synthetic rubber is particularly desirable due to its properties of strength, flexibility, resilience, resistance to wear, and chemical resistance to the bonding solvents. A cover plate 38 is affixed to the base 30 by suitable fastening elements, such as threaded members 42, and is provided with a central circular aperture 40 disposed therein. As shown in FIG. 3, the wiping gasket 34 is fixedly held between the base 30 and cover plate 38, such as by making the wiping gasket 34 of slightly greater thickness than the depth of the recessed portion 32. Thus, when the cover plate 38 is fastened upon the base 30, the wiping gasket 34 can be securely held by compressing it between these two elements.

The apertures 36 and 40 are generally coaxial, and the diameter of aperture 40 is selected to be somewhat greater than the diameter of aperture 36. This permits the inner portions of the wiping gasket 34 that extend radially into the aperture 40 to flex upwardly when a tube is passed in an upward direction through the aperture 36.

Entrance guide bushing 31 is coaxially aligned with apertures 36 and 40. By these means, the entrance guide bushings 31 will function to center an inner tube 4 passing therethrough with respect to the aperture 36 of the wiping gasket 34. The size of the entrance guide bushing 31 that is required will vary in accordance with the outside diameter of a tube 4 that is passed therethrough. For this reason, a set of differently sized bushings should be available in order to select the proper size when processing a number of different outside diameter tubes.

In operation, the amount of solvent removed from the outer surface of tube 4 is dependent upon the amount of force with which the edges of aperture 36 engage the surface of the tube. This force, in turn, is dependent upon several factors, amohg these being the relationship of the

diameter of tube 4 to the effective diameter of the aperture 36 through which the tube must pass and the flexibility, strength, yieldability and resiliency of the gasket 34. For example, if the size of aperture 36 is small in relation to the diameter of tube 4, then the edges of the aperture will grip the core more tightly and remove a greater portion of the solvent from the tube 4 than when the tube is not so tightly gripped. Also it can be readily seen that a gasket of a more flexible and yieldable material will not doctor as much solvent from the surface of the tube 4 as would one of a material which is relatively nonflexible and unyielding.

FIG. 4 shows a second embodiment of apparatus used to effect controlled solvation of tube 4. In this embodiment, a short vertically-disposed vessel 14a is used to contain a continuously circulating solvent bath 15. The vessel 14a includes an entrance gasket 16a and a wiping gasket 18a similar in construction to the construction shown in FIG. 3.

Controlled solvation of tube 4 is, as in the embodiment of FIG. 2, carried out in vessel 14a in the manner as described with reference to FIG. 2. The apparatus of FIG. 4 additionally includes curved guide tube 44 and a spray nozzle 46. This is a safety measure so that if any solvent leaks past gasket 16a, it will be diluted by a flow of a suitable diluent, such as water, onto the core to reduce the possibility of damaging that portion of the tube that is feeding upward toward gasket 16a. Water gravitating to the bottom of vessel 44 is collected and discharged as by a drain 48.

FIG. 5 shows a third embodiment of apparatus for solvating the inner tube 4. In this embodiment, the vessel 14b has its longitudinal axis oriented in a generally horizontal position. The inner tube 4 is fed from supply reel 12b through seal or gasket 16b and into the solvent bath 15 contained in vessel 14b. As in the embodiment discussed above, wiping gasket 18a is of generally the same construction as shown in FIG. 3 and performs a wiping function as described. This form of solvating apparatus is designed for use with braiding or wrapping machines which have yarn carriers that rotate about a horizontal axis as opposed to those which have

yarn carriers that rotate about a vertical axis as illustrated in FIG. 2.

SOLVENT BONDING - PROCESS CONTROLS

1. Temperature Control and Detention Time.

The effect of the solvent on the polymer-- component passing through the solvent bath is a time/temperature dependent parameter. If either the detention time or the temperature is increased, so will be the rate of attack of the solvent on the polymer. In past prior art practice, it was thought important to minimize the detention time and, for that reason, the temperature of the solvent bath was frequently elevated. For example, in the solvent bonding of nyoon, the prior art variously suggests typical temperatures in a range of from about 150°F. to about 200°F. as being suitable with detention times as short as 1.5 seconds.

It has now been found that it is more difficult to maintain process and quality control when the rate at which the solvent attacks the polymer is too high. For this reason - that is, to reduce the rate of attack and thus allow significantly greater leeway for variations in process timing, etc.,- it has been found desirable, contrary to the teachings of the prior art, to run at comparatively low temperatures, and in compensation therefor to increase detention time. In the specific case of bonding a reinforcing yarn to a nylon inner tube, it has been found convenient to work with a resorcinol bath at a low temperature which is relatively easy to maintain. For example, a temperature in the range of 70°-90°F., which ordinarily is slightly below the ambient conditions, is quite easy to maintain by running a small amount of cooling water through heat exchange coils in the solvent bath. On the other hand, if a need should arise to increase the rate of solvation, the temperature of the bath can be raised above the ambient simply by running hot water through the coils. When operating at ambient temperatures, a detention time may typically be from about 20 seconds to about 90 seconds, and will most often fall within the range of about 30 to about 60 seconds.

While ordinarily it is desirable to keep the resorcinol bath, in the case of nylon, at or near ambient conditions, there are times when the rate of solvation must be increased. For reasons not well understood,

certain production lots of nylon inner tubing are sometimes processed which exhibit slower rates of solvation for given solvent conditions and thus require some heating of the solvent system above ambient temperatures. For example, the rate of solvation of nylon and resorcinol is dependent not only upon the type of nylon that is used, but also depends upon the formulation of the nylon, the amount of plasticizers present in the nylon, the molecular weight of the nylon, the molecular weight distribution of the nylon, and the crystallinity of the nylon. In this latter regard, it is believed that resorcinol preferentially attacks amorphous regions of the nylon and that, therefore, if there is an increase in the surface crystallinity of the inner tube, the rate of solvation will decrease.

2. The Solvent.

As previously mentioned, this invention is largely based on the fact that only a minimum amount of solvent need be used to obtain consistently good bonds if the important control variables are held reasonably constant. To this extent, it is not as important to select proper physical and chemical properties of the solvent as it is to maintain them once they are selected. For this reason, the following discussion is not so much directed toward the specific physical and chemical properties that must be selected as it is to a discussion of which physical and chemical properties will cause variations in the process if they are not uniformly maintained.

Of the more obvious physical properties that affect the rate of solvation are the wetability and viscosity of the solvent. These can be adjusted by known methods such as by the use of surface active agents, by altering the temperature, or by adjusting the composition of the solvent as through changing the dilution.

The concentration of the solvent is, of course, important, and in the case of a resorcinol bath for solvating nylon, it has previously been believed that adequate control over the concentration can be maintained by monitoring the specific gravity of the solvent bath. While this is true when an initial batch of resorcinol and water solution is prepared, it has not generally been recognized that the specific gravity of the solution is also

affected by the nylon that goes into solution as the tube passes through the bath. Essentially, about three factors are continuously affecting the specific gravity of the solution. First, the preferential withdrawal of solvent from the bath will tend to cause a decrease in the specific gravity of the solution. Second, a smaller amount of water is withdrawn from the bath and this will tend to decrease the specific gravity. Third, some indeterminate quantity of nylon is added to the solution which will cause an increase in the specific gravity. Thus, it has been discovered that the specific gravity of the solvent is not necessarily a reliable index, in and of itself, of the effectiveness for or the rate of solvating a polymeric material.

The strength of the solvent should be adjusted depending upon the polymeric material being solvated. For example, if the hose is of a plasticized copolymer of type 6 and 6/6 nylon, a suitable solvent solution can be prepared by mixing 1 part by weight of resorcinol into 2 parts by weight of water. If a less soluble nylon is used, such as type 6 nylon, the strength of the solution is increased by admixing the resorcinol in a 1:1 proportion to the water. In the former case a specific gravity in the range from about 1.053 to 1.073 should be maintained, whereas in the latter case, the range may be from about 1.095 to 1.117.

3. Time Interval Before Wrapping Tubing

Previous reference has been made to the time interval, which is the elapsed time after the hose component leaves the solvent bath before it is contacted with another component, hereinafter referred to as the "time gap". Specifically, with regard to the apparatus illustrated in the drawings, the time gap is the difference in the time at which the tubing leaves the wiping element 18 and the time at which it is contacted by the high tensile strength yarns. The importance of the time gap lies in the fact that the longer the time difference, the greater the opportunity of the solvent to penetrate into the tube. As the solvent penetrates or migrates into the tube, less and less solvent remains on the surface to bond the reinforcement yarns. Thus, it can be said that the greater the time gap, the greater is the amount of solvent that must be applied to the inner tube in the solvent bath to ensure

a sufficient amount on the surface for bonding. Since one of the important purposes of this invention is to minimize the amount of solvent that is applied, it becomes important to reduce the time gap to a minimum. To do this, solvating vessels 14, 14a and 14b, as illustrated in the drawings, are specifically designed so that they are adapted to be positioned directly adjacent the entrance of the spiral wrapping or braiding apparatus so that the time gap can be reduced to but a few seconds. In the preferred practice of this invention, the time gap should be less than 30 seconds, and more preferably, less than 20 seconds.

4. Control of Solvent Carried On Hose Component.

In addition to controlling the solvation of the tube passing through the bath by means of temperature regulation, adjustment of detention time, maintaining specified solvent strength, and like parameters, the amount of solvent removed from the solvent bath is also a function of the amount of solvent that is retained on the surface of the hose as it leaves the solvation vessel. The device shown in FIG. 3 is designed to minimize the withdrawal of solvent from the tank by providing a tight flexible gasket to doctor all excess liquid from the surface of the tube as it leaves the solvation vessel. It has been found that in an ideal operation, in the case of a nylon tube and a resorcinol bath, best results are obtained when the action of the wiper is sufficiently effective to leave the surface of the tube dry to the touch.

EXAMPLE I

Apparatus as schematically illustrated in FIG. 2 was utilized to bond a high tensile strength yarn reinforcing member to an inner tube 4. The inner tube 4 was formed by the extrusion of a type 6 nylon resin sold under the trade designation "PLASKON 8215" by Allied Chemical Corporation. The tube was led through a solvating vessel 14 which vessel was then filled with a solvent solution that was prepared by adding one part by weight resorcinol to one part by weight water. A circulating pump 23 was energized to cause the solvent solution to circulate continuously between the solvating vessel 14 and the supply tank 22. By means of cooling coils

28 located within the supply tank 22, the solvent solution was adjusted to and maintained at a temperature of 80° F. The hose at the exit end of the solvating vessel 14 was engaged with a braiding machine 25 and its end secured to takeup reel 26. The braiding machine was then started and the speed of advance of the tube through the system was adjusted so that the immersion time of the tube 4 within the solvating vessel 14 was in a range of from forty to sixty seconds. When operating conditions had stabilized, excess solvent was doctored from the tube by the wiping gasket 18 to the extent that the tube was essentially dry to the touch. From there the tube was immediately led to the braiding machine and, due to the close proximity of the exit of the solvating vessel to the braiding machine, the average time interval to wrapping was held to less than twenty seconds. At the braiding machine, various deniers of a high tensile strength type 6/6 nylon were applied varying from about 2000 to about 8000 denier. During operation, the solvent solution within the supply tank 22 was monitored and the specific gravity maintained in a range of from about 1.100 to 1.112.

The reinforced hose produced by the foregoing process had uniform and consistent properties. In addition to its high burst strength and relatively small elongation under pressure, the hose produced by this process had a braid pullback rating of over 45 pounds per inch of circumference.

The construction of the above hose was then completed by applying a nylon outer cover over the braided reinforcing member in a manner substantially in accordance with the teachings of United States Patent No. 3334165.

EXAMPLE II

The process of Example I above was repeated, but in this example a plasticized copolymer comprised of 6 and 6/6 nylons sold under the trade designation "ZYTEL 91A" by duPont was substituted. To compensate for the more rapid solvation of this material as compared with type 6 nylon used in Example I, the solvent solution was prepared using one part by weight resorcinol to two parts by weight water, and the specific gravity was controlled within the range 1.057 to 1.068 @ 80° F. Braid pullback characteristics as noted in Example I were consistently obtained.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method for the manufacture of a reinforced high pressure hose made from synthetic polymeric components in which the first component is an inner nylon tube and the second component is at least one reinforcing wrapping of a high tensile strength nylon yarn, which second component, at least at its interface with the tube, is solvent-bonded to the tube, comprising the steps of:

- contacting the surface of the tube with a liquid solvent for the tube at ambient temperature for a sufficient time to solvate only the outer surface of the tube, said time being an interval of from about 20 to about 90 seconds;
- withdrawing the tube from the solvent and removing all excess solvent from the surface of the tube;
- applying a reinforcing wrapping of nylon yarn about the surface of the tube within 30 seconds after the tube is removed from the solvent, as spiral wrappings of said yarn applied in opposite circumferential directions;
- bonding the yarn to the tube under conditions that will permit the solvent applied in the solvent bath to remain in the hose structure; and,
- applying a thin polymeric protective cover under conditions to bond said protective cover to said second component.

2. A method according to Claim 1 wherein the second component is a reinforcing wrapping applied as two consecutive wrappings of spirally wound nylon yarn.

3. A method according to Claim 1 wherein the second component is a reinforcing wrapping applied as a braid formed of intermeshed pluralities of spirally wound nylon yarns.

4. A method according to Claims 2 or 3 wherein the solvent is comprised of a solution of water and resorcinol.

5. A method according to Claim 2 or 3 wherein the solvent is comprised of a solution of water and resorcinol and the solvent is maintained at about ambient conditions.

6. A method according to Claim 2 or 3 wherein the detention time of the tube in the solvent is between about 30 seconds and about 60 seconds.

7. A method according to Claim 2 or 3 wherein the tube is a plasticized copolymer of nylon-6 and nylon-6/6 and the specific gravity of the solvent comprised of a solution of water and resorcinol is maintained in a range of from about 1.053 to about 1.073.

8. A method according to Claim 2 or 3 wherein the tube is nylon-6 and the specific gravity of the solvent is maintained in a range of from about 1.095 to about 1.117, said solvent being a water solution of resorcinol maintained at ambient conditions.

9. A method according to Claim 2 or 3 wherein the time interval after the tube is removed from the solvent until the reinforcing component is applied is less than 20 seconds.

10. A method according to Claim 2 or 3 wherein the solvent is comprised of a solution of resorcinol in water and the excess solvent is removed from the tube as it leaves the solvent bath by means of a flexible gasket having a wiping aperture through which the tube is passed.

FIG. 3

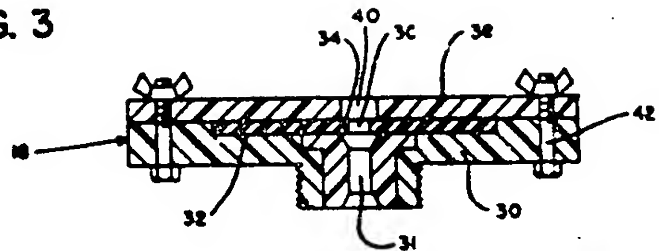


FIG. 4

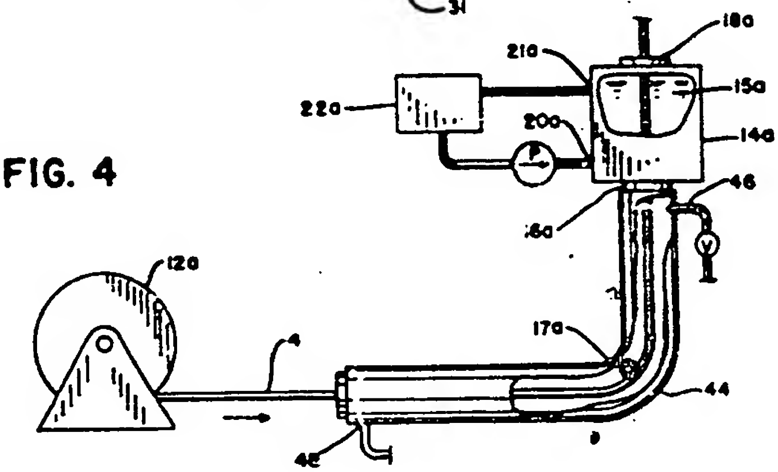
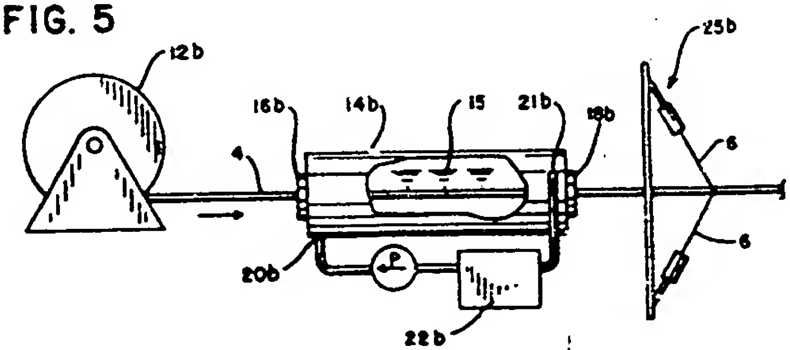


FIG. 5



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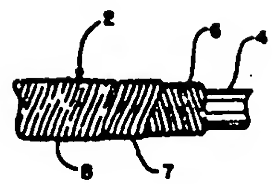

FIG. 1

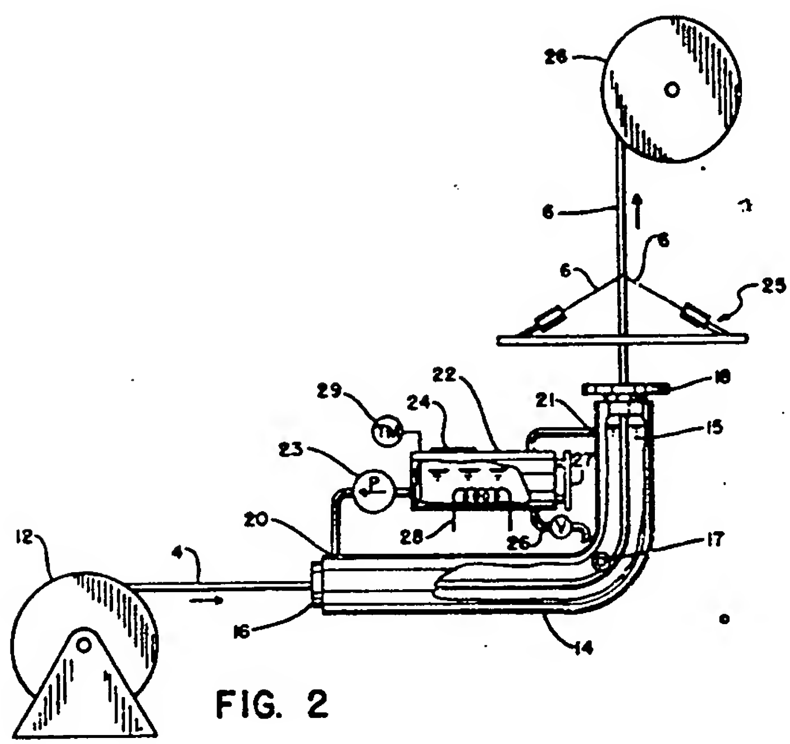

FIG. 2